RESEARCH SUMMARY

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NELSON FOREST REGION

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Ecological Interrelationships of Three-Toed Woodpeckers with Bark Beetles and Pine Trees

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■ Pest management programs aimed at reducing the incidence and habitat of bark and wood-boring beetles should consider potential negative impacts on wildlife species that depend on the beetles and their host trees.

INTRODUCTION

The three-toed woodpecker (*Picoides tridactylus*) is an inconspicuous year-round resident of British Columbia's forests (Figure 1). In the BC interior, the species is found mainly in lodgepole pine and spruce-dominated stands of the Interior Cedar-Hemlock (ICH) and Engelmann Spruce-Subalpine Fir (ESSF) biogeoclimatic zones.

The three-toed woodpecker is thought to perform an important ecological role in forested areas because it preys almost exclusively upon the larvae and pupae of bark beetles (i.e. mountain pine beetle (MPB) *Dendroctonus ponderosae*, and spruce beetle *Dendroctonus rufipennis*) and a variety of woodborers (i.e. insect families *Cerambycidae* and *Buprestidae*). Evidence suggests that three-toed and other woodpeckers contribute to the natural regulation of beetle populations by maintaining beetles at endemic levels, by delaying the onset of a population outbreak, or by accelerating population decline (Machmer and Steeger 1995).

The significance of these ecological processes is clear if one considers that timber losses in BC from mountain pine beetle infestations in 1993 alone amounted to 2.7 million m^3, which represents about 18% of the annual lodgepole pine harvest (Wood and Van Sickle 1993).

The British Columbia Ministry of Forests (MOF) maintains an aggressive pest management program which includes extensive harvesting of beetle-infested stands and stands susceptible to infestation. However, such widespread alteration of bark beetle habitat may have serious negative conservation implications for three-toed woodpeckers and other organisms that co-evolve with these beetles and their host trees. The province is committed to maintaining populations of all species across their natural range, and some recommendations that address the dependence of wildlife on beetles have been put forward in the Forest Practices Code (FPC). For example, the FPC Biodiversity Guidebook (p.72) recommends that "during tree pest and disease treatments, some areas should be left untreated."

Research in the Nelson Forest Region addresses this recommendation through an in-depth study of the demography and habitat use of a local three-toed woodpecker population. The long-term goal is to provide more specific guidelines regarding the amount, location, and composition of leave patches in pest management operations.

The study was initiated in the spring of 1995. The study area, located in the Deer Creek watershed of Arrow Forest District, is currently inhabited by an endemic MPB population. Small, localized beetle outbreaks have occurred over the last 10 years and large stands of susceptible lodgepole pine are distributed throughout the watershed. Approximately 40% of the lodgepole pine volume has recently been harvested, with more harvesting scheduled at a rate approaching 20 000 m^3/y. The Deer Creek watershed thus offers an opportunity to investigate a woodpecker population that is experiencing

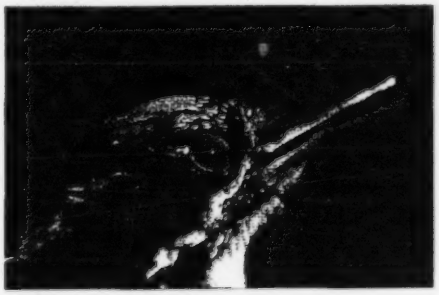

Figure 1. Three-toed woodpecker.

drastic habitat reduction. The study is now concluded. This Research Summary presents results from the 1996 summer field season and integrates relevant data from 1995 and winter 1996.

The specific objectives of the 1996 field season were to:

1. Band breeding three-toed woodpeckers and their young for individual identification (and for eventual calculation of mortality and fecundity rates).
2. Determine clutch size, brood size, and fledging success of three-toed woodpeckers.
3. Describe the trees used by three-toed woodpeckers for nesting and feeding.
4. Determine home range size of breeding three-toed woodpeckers.

It is anticipated that the ecological information on individual woodpeckers can eventually be correlated, through GIS (geographic information system) mapping, with the harvesting prescriptions used in the lodgepole pine stands of the Deer Creek watershed. This information can then be used to develop a general model which integrates wildlife habitat conservation with pest management efforts aimed at minimizing timber losses in lodgepole pine stands.

STUDY SITE

The Deer Creek watershed is located along the eastern side of Lower Arrow Lake, approximately 30 km west of Castlegar. The area surveyed for woodpeckers lies within the Interior Cedar-Hemlock dry warm and moist warm variants (ICHdw and ICH mw2). Elevation of the area surveyed ranges from 700 to 1500 m. Stands are approximately 70-90 years old and are dominated by lodgepole pine (Pinus contorta) and Douglas-fir (*Pseudotsuga menziesii*), with minor components of western larch (*Larix occidentalis*), western redcedar (*Thuja plicata*), paper birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*).

STUDY METHODS

From May through August, road and line transect surveys were conducted to locate three-toed woodpeckers and their nests within the study area. Sampling areas included recent and current logging sites. When a nesting cavity was discovered, its progress was monitored at least once per week. The number of eggs or chicks present was determined. Each captured adult and chick was permanently banded. To determine home range size and to track foraging movements, six adult woodpeckers were fitted with radio transmitters.

Nest trees were described with respect to species, diameter at breast height (dbh), height, decay class (1-7 of BC Wildlife Tree Classification System), and height of active cavity. Also, forage trees were described with respect to length of time they had been under attack by MPB. If needles on beetle-attacked pine were still green, woodpeckers were considered to be feeding primarily on MPB. If needles had turned red, they were likely feeding on secondary woodboring beetles (e.g. *Ips pini*); and if no needles were present, the birds were certainly feeding on secondary woodborers.

RESULTS AND DISCUSSION

Banding and Radiotelemetry

A total of 26 three-toed woodpeckers (15 adults and 11 chicks) were banded: 16 during 1996 and 10 during the previous breeding season. Fifteen of eighteen known nesting adults were banded. Six banded individuals were subsequently re-sighted, but several unbanded ones were also detected. At the time of writing this Summary, it was unclear what proportion of the Deer Creek population was banded. During the 1996 breeding season, radiotracking did not generate sufficient telemetry data for analysis of home ranges, mainly because nests of radio-tagged birds failed during the nestling period. One chick banded in 1995 was found breeding in 1996, approximately 250 m from where it was born, which is a very short dispersal distance. Continued banding and telemetry efforts will allow a better understanding of long-term population trends, and the birds' habitat requirements and movements.

Breeding

During the 1995 and 1996 breeding seasons, the study located 13 active three-toed woodpecker nests in the Deer Creek watershed (Figure 2). Although 38% were located in lodgepole pine (Table 1), five different tree species were used for nesting. Of the seven woodpecker species that occur in the study area (see Steeger and Machmer 1995), the three-toed woodpecker has shown the greatest variation with respect to choice of tree species for nests.

All active nests were located in mature trees with a mean dbh of 26.1 cm and mean height of 21.0 m (Table 1). Most nest trees were still alive but showed signs of disease or defects (decay class 2). Of the five lodgepole pine nest trees, three had been attacked by MPB. Nest cavities were located relatively close to the ground (Table 1).

In 1996, between 2 and 4 eggs were laid per adult female (Table 2) with an average clutch size of 3.4 (sd = 0.8, n = 7). This agrees with an average of 3-4 reported for this species in North America by Winkler et al. (1995). Seventy-five percent of the eggs hatched, which is higher than the 60% reported by Winkler et al. for three-toed woodpeckers. However, of the seven nesting attempts that were followed to

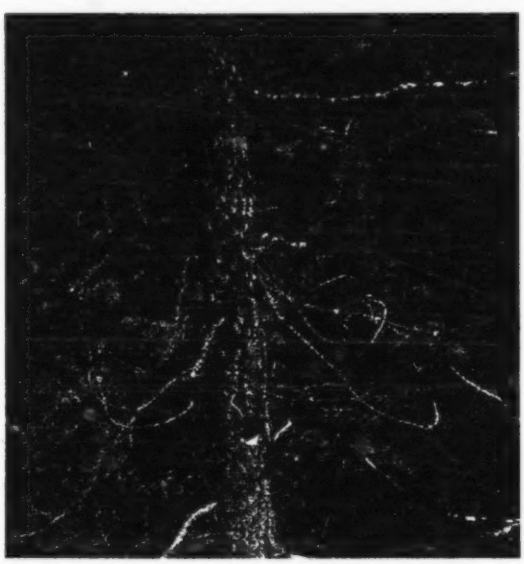

Figure 2. Three-toed woodpecker outside its nest.

conclusion, nesting success (determined by the fledging of at least one chick) was only 42.9%. Of the three successful nests, two fledged only one chick and the third may have fledged two at the most. In comparison, Goggans et al. (1989) found a 53% (n = 15) nesting success for this species in lodgepole pine stands of central Oregon, with a higher nest failure rate being observed in logged areas.

Several factors contribute to explaining what caused the low productivity of woodpeckers at Deer Creek in 1996. The laying period produced a relatively high number of eggs; hence, it was the period between hatching and fledging that was so detrimental to the reproductive success of the woodpeckers. In the nests that managed to fledge at least one chick, it appears that a reduction in the number of hatchlings may have been due to a shortage of food. For example, in Nest No. 5 two healthy chicks were seen on June 26, but two days later the adult male was observed pushing a dead chick out of the cavity (Table 2). The corpse of the chick appeared very emaciated (as did the dead chicks from Nest No. 9). If the mortality was due to starvation, one hypothesis is that the relatively cold and wet spring of 1996 negatively affected the adults' foraging efficiency. Alternatively, the drastic reduction of bark beetle host trees (i.e. lodgepole pine) due to logging within the home range of the monitored pairs may have caused a food shortage for the nestlings. In at least one case, the nest was depredated, with the chicks being killed within the cavity. Woodpecker nests are increasingly vulnerable to attack during the nestling period because the developing chicks produce increasingly louder begging calls, especially when they are underfed. Small predators such as squirrels, weasels, and mice have been known to enter the cavities and eat eggs and/or chicks of woodpeckers, and even adults if they are present.

Feeding

During the winter of 1996/97, three-toed woodpeckers fed primarily upon beetles on lodgepole pine (Table 3). The pine were, on average, greater than 23 cm in diameter and most had recently been killed (decay class 3) by mountain pine beetles and the blue stain fungus introduced by mountain pine beetles. Most other conifers used for foraging had also recently died. Almost all trees used by the three-toed woodpeckers showed signs of previous foraging activities (i.e. scaling or feeding excavations), suggesting frequent re-use of individual trees.

Further analysis of lodgepole pines revealed that 23% were still "green" (i.e. mountain pine beetle larvae were present in the tree), and 16% and 56% were "red" and "gray" respectively, while 5% could not be classified. These results indicate that adult three-toed woodpeckers feed primarily on secondary beetles and woodborers in winter. Because of a different research emphasis in summer, the dataset on summer foraging is still too small

Table 1. Nest tree and cavity characteristics of active three-toed woodpecker nests in the Deer Creek watershed, summer 1996.

Tree species [a]	n	dbh [b] (cm)	Height [b] (m)	Decay class (median)	Cavity height [b] (m)
Pl	5	20.7 (3.9)	17.8 (9.2)	2.0	4.2 (1.9)
Lw	3	34.0 (6.4)	22.7 (10.2)	3.0	6.3 (3.7)
Fd	2	24.3 (2.0)	20.2 (7.9)	2.0	7.0 (5.0)
Cw	1	31.5 (-)	19.2 (-)	1.0	2.8 (-)
At	2	26.7 (7.1)	28.5 (3.0)	1.5	5.8 (0.5)
Combined	13	26.1 (6.9)	21.0 (8.1)	2.0	5.2 (2.7)

[a] Pl = lodgepole pine. Lw = western larch. Fd = Douglas-fir. Cw = western redcedar. At = trembling aspen. [b] Values are means (sd).

Table 2. Results of three-toed woodpecker nesting attempts in the Deer Creek watershed, summer 1996.

Nest No.	Eggs (no.)	Hatched (no.)	Fledged (no.)	Comments
1	3	3	1	Two chicks died, unknown reasons.
2	4	3	0	Possibly depredated.
3	3	3	0	Depredated.
4	2	2	?	Cavity too high to monitor regularly.
5	4	2	1	One chick died, unknown reasons.
6	4	3	1 or 2	Confirmed only one fledgling.
7	?	?	?	Cavity too high to monitor.
8	?	3	0	Nest failed, unknown reasons.
9	4	2	0	Chicks likely died of starvation.

Table 3. Tree species used for feeding by three-toed woodpeckers in the Deer Creek watershed, winter 1996.

Tree species [a]	n	% of total observ.	dbh [b] (cm)	Decay class (median)	% trees with previous feeding
Pl	217	79	23.1 (4.5)	3	95
Fd	30	11	17.8 (13.5)	3	80
Sx	13	5	30.1 (14.4)	4	92
Lw	12	4	28.7 (14.7)	3	92
Pw	2	0.7	57.5 (2.0)	3	100
Hw	1	0.3	31.0 (-)	3	100
Combined	275	100	26.1 (6.9)	3	93

[a] Pl=lodgepole pine. Fd=Douglas-fir. Sx=hybrid spruce. Lw=western larch. Pw=white pine. Hw=western hemlock. [b] Values are means (sd).

for analysis. However, interesting questions emerge: do three-toed woodpeckers feed mountain pine beetle larvae to their young, and do they require these beetles for successful reproduction? Early summer is the time of highest demand on woodpecker parents to supply food to nestlings, which coincides with the time when beetle larvae are largest. Considering the declining availability of mountain pine beetle larvae due to logging in the Deer Creek watershed, this might explain the poor reproductive success experience by the three-toed woodpeckers during summer 1996. Although further research is required to determine how these woodpeckers respond to habitat loss, some preliminary conclusions can be drawn.

CONCLUSIONS AND RECOMMENDATIONS

1. Reproductive success of three-toed woodpeckers at Deer Creek was low in 1996. Mature beetle-attacked lodgepole pine is important as a nest tree and is clearly the primary tree species for feeding. However, there is a need to further determine:
   (i) whether reproductive success is associated with extensive salvage and suppression logging of lodgepole pine stands. Comparisons with brood success in unharvested areas are needed.
   (ii) the extent to which woodpeckers depend on bark beetles and associated insects for food.
   (iii) whether stand fragmentation affects woodpecker densities.

2. Banding and radiotelemetry are essential for generating reliable population and habitat information, but radiotelemetry efforts have to be increased to produce conclusive results on habitat selection, home range size, and dispersal.

3. The three-toed woodpecker and its prey appear to be a model system for a study on forest health and the potential impacts of natural predators on bark and wood-boring beetles. In addition, the species appears to be a suitable subject for investigating potential effects of salvage and suppression logging on wildlife. It should be noted that three-toed woodpeckers excavate new cavities each year, and that many of these cavities are subsequently occupied by secondary cavity users such as the northern flying squirrel (*Glaucomys sabrinus*) which are unable to excavate their own cavities. The three-toed woodpecker might therefore be functioning as a keystone species within lodgepole pine stands by influencing the abundance and composition of organisms (i.e. lodgepole pine, beetles, and squirrels, among others) and the ecological processes that these organisms themselves influence and are essential parts of (see Machmer and Steeger 1995).

4. For lodgepole pine stands, it is recommended that wildlife tree patches be retained within cutblocks. These patches should contain a mixture of live and dead lodgepole pine, including large old trees, trees of poor vigour, and trees that have recently been attacked by mountain pine beetles (aka green attack).

In general, pest management programs aimed at reducing the incidence and habitat of bark and wood-boring beetles should consider potential negative impacts on wildlife species that depend on the beetles and their host trees. For the three-toed woodpecker, bark beetles are the key to reproduction and survival.

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